NAIC-ID(RS)T-0067-95

NATIONAL AIR INTELLIGENCE CENTER

AIR INTELLIGENCE AGENCY

NEW GENERATION OF SPACE BATTERIES--GaAs SOLAR CELLS

by

Zhang Zhongwei, Shi Wenzao

NATIONAL AIR INTELLIGENCE CENTER

HUMAN TRANSLATION

NAIC-ID(RS)T-0067-95 15 May 1995

MICROFICHE NR: 95C000311

NEW GENERATION OF SPACE BATTERIES--GaAs SOLAR CELLS

By: Zhang Zhongwei, Shi Wenzao

English pages: 7

Source: Aerospace China, Nr. 11, November 1991; pp. 14-15

Country of origin: China
Translated by: SCITRAN
F33657-84-D-0165
Requester: NAIC/TATD/James R. Shell, 0-2
Approved for public release: Distribution unlimited.

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

Accesion For	
NTIS CRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and / or Special
A-1	

NEW GENERATION OF SPACE BATTERIES--GaAs SOLAR CELLS

Zhang Zhongwei   Shi Wenzao

ABSTRACT

This paper describes a new generation of space power sources--GaAs solar cells--and the status of their development inside China and abroad. In conjunction with this, on the basis of unique properties associated with GaAs solar cells, it points out the direction of development, clarifies the value of key space applications, and, finally, forecasts the application prospects for GaAs solar cells.

KEY TERMS Space power source   GaAs   China

I. INTRODUCTION

From 1958 to the present, the development of the electric power of solar cells acting as space power sources has been unusually rapid. From a few watts initially, they have developed to the present 40 kW. Single sheet cells and square matrix techniques have advanced and improved by the day. Powers have risen from the original 8-10% to the current 12-15% (AMO). Space application reliability has clearly improved, and life has been very greatly extended. At the present time, 90% of the choices for power sources to use in spacecraft are power source systems associated with square solar cell matrices and added sets of storage batteries. Moreover, among solar cell arrays, besides an extremely small number opting for the use of GaAs solar cells, the remainder all opt for the use of monocrystalline silicon solar cells.

GaAs solar cells are III-V family compound semiconductor components, and, compared to monocrystalline silicon solar cells, they possess higher power, better resistance to high temperatures, counter irradiation properties, as well as larger

specific powers, and other such advantages. As a result, they are the new generation of space power sources with the best prospects for development at the present time.

II. STATUS OF GaAs SOLAR CELL DEVELOPMENT ABROAD

The first time in the world when it was discovered that GaAs material possesses photovoltaic effects was 1954. In 1956, Loferski established the relationship between solar cell conversion efficiency and material sustainment zone width, that is, material associated with a sustainment zone width of 1.4 ~ 1.6ev possesses the highest photoelectric conversion efficiency. The sustainment zone width associated with GaAs materials is 1.43ev. Because of this, they are able to obtain very high conversion efficiencies (theoretical values can reach 28%, AMO, 1 sun).

In 1962, development personnel made the first zinc adulterated GaAs solar cell. Conversion efficiency was 9 ~ 10%-- far lower than the theoretical value. In 1972, research personnel opted for the use of liquid phase extension techniques to grow, on GaAs surfaces, an optically transparent broad sustainment zone window layer, very greatly reducing compounding on surfaces of light induced current carriers, causing conversion efficiencies to clearly increase to 16%. Later, they increased again to 21%. From this, the foundation of high efficiency GaAs solar cells was laid.

After entering the 1980's, development of GaAs solar cells clearly speeded up. The basic reasons were that space competition increased in intensity, requirements for space energy source systems got higher and higher, and GaAs solar cells, on the basis of their superior characteristics, got high levels of attention from the space departments of various countries day by day. Besides this, one factor which cannot be ignored is that

the two key technologies which were used to develop GaAs solar cells--CPE technology and MOWD technology--were already maturing with each passing day. At the present time, such countries as the Soviet Union, the U.S., Japan, and so on, all aggressively develop GaAs solar cells. In conjunction with this, they have achieved very great accomplishments. GaAs solar cells are just in the process of transitioning from a laboratory research stage to a stage of practical use in space. Cell areas have already developed from 2x2 cm^2 and 2x4 cm^2 to 4x4 cm^2. Cell efficiencies associated with production in large batches have already reached 18 ~ 19% (AMO). In conjunction with that, a series of environmental simulation tests and tests checking practical usefulness under space conditions were carried out on the cells, clearly proving that GaAs cell properties completely suit the requirements of space applications.

III. STATUS OF GaAs SOLAR CELL PROGRESS DOMESTICALLY

China began developing GaAs solar cells in 1979. By 1985, small area GaAs solar cell conversion efficiencies had already exceeded 20% (AM1, 0.3cm^2). In the "75" period, large area GaAs solar cells for satellite use, developed together by the Aviation and Spaceflight Ministry's Shanghai New World Power Source Plant and the Academia Sinica Shanghai Metallurgy Research Institute, on 26 November 1990, went through Aviation and Spaceflight Ministry department level appraisal. The key results were:

/15

1. 2x2cm^2 GaAs solar cell efficiencies had already reached 17% (AMO). As far as GaAs cells developed in small batches are concerned, more than half of the efficiencies were not below 16%.

2. GaAs solar cells smoothly passed various types of strict space and ground environment simulation tests.

3. The Fengyun No.1(A) weather satellite launched on 7 September 1988 successfully carried out space standardization tests on GaAs solar cells. Standardization precision was +0.24 and reached foreign standardization levels for the same types of product.

4. The Fengyun No.1(B) satellite launched on 3 September 1990 successfully carried out electric power output tests on a 4W GaAs solar cell composite (composed of 54 GaAs cell sheets). Telemetry data clearly proved that cell properties were stable and operations normal.

Environmental simulation tests and actual space environment check tests carried out on GaAs solar cells clearly show that domestically developed GaAs cells are capable of satisfying the requirements of actual use in space.

The key "85" project "High Efficiency GaAs Solar Cell Research" has already begun to be carried out. There will certainly be new breakthroughs in the areas of increasing efficiencies and batch processes.

IV. GaAs SOLAR CELL DEVELOPMENT TRENDS

No matter whether it is the present time or hereafter, the development direction of GaAs solar cells is to increase efficiency and lower costs.

1. Developing High Power Light Gathering Cells

Making adequate use of the high temperature resistance characteristics of GaAs solar cells (they can function normally under 200°C), it is possible to make high power light gathering cells (their light gathering ratio can reach 1000), to bring into play the superiority of high efficiency GaAs solar cells. At the

present time, outside China, light gathering cells have already been developed with efficiencies as high as 28.1% (AM1.5, 400 suns). Through further development, making efficiencies as high as 30% is entirely possible.

2. Developing Multiple Series Connected Cells and Mechanically Stacked Multiple Light Gathering Cells (MSMJ Cells)

(1) In 1988, the U.S. Raytheon Company developed a successful single sheet double connection cell with efficiency reaching as high as 22.3% (AMO, 1 sun).

(2) In 1988, the Raytheon Company developed GaAs/Si MSMJ cells with conversion efficiencies reaching 31% (AM1.5, 347suns)--the first time 30% was broken through. In July of 1989, the U.S. Boeing Company also developed efficiencies reaching as high as 37% (AM1.5, 100mW/cm , Entech prism cover plate) with a new model of GaAs/GaSb series connected light gathering solar cells. High efficiencies associated with GaAs MSMJ cells, in lowering solar cell costs, increase competitive power with conventional electric sources. This area has important significance.

3. Developing High Efficiency Thin Film Cells

GaAs material is a direct transition type semiconductor. Moreover, sunlight absorption coefficients are large. Some 5 micron thicknesses are adequate to absorb over 90% of optical energy. Using this characteristic, it is possible to make thin film GaAs cells. Conversion to thin films is a key measure for greatly reducing GaAs cell costs. Speaking in terms of space applications, thin film cells are, then, capable of very greatly reducing solar array weight, that is, they are capable of very greatly increasing the weight specific powers. At the present time, the efficiency of the thin film GaAs cell developed by the U.S. Kopin Company has already reached 22.4% (AM1.5, 1 sun).

4. Developing GaAs Solar Power Cells Manufactured on Inexpensive Bases

On such bases as Si, Ge, Ge/Si, and so on, light weight, high efficiency GaAs solar cells are manufactured. At the present time, what is focusing attention is GaAs solar cells manufactured on Ge bases. Their properties have already approached solar cells manufactured using GaAs single crystal bases. Moreover, costs are low, strength is high, and, therefore, GaAs/Ge cells are seen as the most promising replacements for expensive GaAs monocrystalline solar cells in the 1990's, acting as the main space power source.

V. SPACE APPLICATION PROSPECTS FOR GaAs POWER SOURCES

Due to the good properties of GaAs solar cells, the spaceflight departments of such countries as the Soviet Union, the U.S., and Japan, early on, lined up in the direction of and did not hesitate to introduce huge funding for the development of GaAs solar cells. In recent years, technologically, great breakthroughs have been achieved. A number of large companies such as the U.S. Hughes, ASEC, optical source laboratories, Spine, as well as Japan's Mitsubishi and so on have all already formed production scale, batch process cells associated with several tens of thousands of sheets. Average efficiencies are 18% (AMO, $2x4cm^2$, $2x2cm^2$) and have already reached levels at the stage of practical use in space. On this technological foundation, in early 1988, Japan already launched the CS-3 communications satellite making use of solar arrays composed entirely of GaAs solar cells. The square matrix in question is composed of 80 thousand $2x4cm^2$ sheets of GaAs solar cells. Average cell efficiencies are 18.9% (AMO). The U.S. and the Soviet Union have also carried out tests long ago on GaAs solar cells in association with satellite launches. In conjunction

with this, there are preparations, in the early 1990's, to launch long life satellites with main power sources which are square matrices completely made up of GaAs solar cells. Without doubt, progress in space applications of GaAs solar cells will accelerate continuously.

Summarizing what was said above--following along with further increases in GaAs solar cell development levels--they will gradually replace the monocrystalline silicon solar cells which are commonly used at the present time (in particular, in situations where there are also limitations on efficiencies, length of life, and array area), and will become ideal main power sources for such spacecraft as man-made satellites, spaceships, and space stations.

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION	MICROFICHE
B085 DIA/RTS-2FI	1
C509 BALLOC509 BALLISTIC RES LAB	1
C510 R&T LABS/AVEADCOM	1
C513 ARRADCOM	1
C535 AVRADCOM/TSARCOM	1
C539 TRASANA	1
Q592 FSTC	4
Q619 MSIC REDSTONE	1
Q008 NTIC	1
Q043 AFMIC-IS	1
E051 HQ USAF/INET	1
E404 AEDC/DOF	1
E408 AFWL	1
E410 AFDTC/IN	1
E429 SD/IND	1
P005 DOE/ISA/DDI	1
P050 CIA/OCR/ADD/SD	2
1051 AFIT/LDE	1
P090 NSA/CDB	1
2206 FSL	1

Microfiche Nbr: FTD95C000311
NAIC-ID(RS)T-0067-95